

## Developments in the United Kingdom road transport from a smart cities perspective

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### Abstract

**Purpose:** Smart city is a city which functions in a sustainable and intelligent way, by integrating all of its infrastructures and services in a cohesive way using intelligent devices for monitoring and control, to ensure efficiency and better quality of life for its citizens. As other countries globally, UK is keen for economic development and investment in smart city missions to create interest in monetary environment and inward investment. This paper explores the driving forces of smart road transport transformation and implementation in the UK.

**Design/methodology/approach:** The study involved interviews with sixteen professionals from the UK road transport sector. A semi-structured interview technique was used to collect experts' perception, which was then examined using content analysis.

**Findings:** The results of the study revealed that the technological advancement is a key driver. The main challenges faced for the implementation of smart city elements in the UK road network are: lack of investment; maintenance; state of readiness and the awareness of the smart road transport concept. The study concludes that an understanding of the concept of smart cities from a road transport perspective is very important to create awareness of the benefits and the way it works. A wider collaboration between every sector is crucial to create a successful smart city.

**Originality/value:** The study contributes to the field of digitalisation of road transport sector. This paper reveals the key driving forces of smart road transport transformation, the current status of smart road transport implementation in UK and challenges of the smart road transport development in the UK.

## Introduction

Enormous global urbanisation and growth has caused migration of people in urban areas and spatial development of urban infrastructure. According to Obaidat and Nicopolitidis (2016), 85-90% of the world population evolution is a result of a 21<sup>st</sup> century cities. Therefore, smart cities are being created from scratch or being developed gradually by improving the prevailing cities infrastructure and primary resources. A study of McKinsey Global Institute's by Department for Business innovation and Skills (2013) shows that more than 50% of the global GDP (Gross Domestic Product) is generated in the 190 major cities in the developed countries compare to 22 largest cities in the developing countries. However, the increase of growth in the developed countries is healthy but this phenomena also set a high expectation on public services and the quality of the urban infrastructure and environment.

Due to the urbanisation, more problems such as overpopulation, pollutions, scarcity of natural resources, public and private services are being created (Yigitcanlar et. al. 2020, Dameri, 2014). Smart cities are an emerging strategy to mitigate the problems generated by the rapid urban population growth and rapid urbanization (Prakash, 2019). A 'smart city' is defined as an urban area that is highly innovative in terms of overall facilities, ecological real estate, communication and market feasibility (Chirisa *et al*, 2016). Also, smart cities is defined as "a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefits of its inhabitants and businesses" (Kumar *et al.*, 2018). Whereas BSI (2014) noted that smart cities as an effective integration of physical, digital and human systems in a built environment to deliver sustainable, prosperous and inclusive future for its citizens. From the above three definitions, it could be inferred that smart cities are cities that make use of physical, digital and human systems in order to enable sustainability and efficiency for the citizens within that city.

The economic growth of any country is supported by its good infrastructure. The United Kingdom (UK) has strategic roads, railway and airports; however, it is one of the top 10 most congested country in the world (Korosec, 2018). According to ONS (2017), the population in the UK in 2016 was 65.6 million which was the largest ever. It is also projected that the population in the UK would grow, reaching over 74 million by 2039. Due to the population rise amalgamated with increase of cars on the road, which has increased by 4.6% higher than the previous peak in 2016 (Department of Transport, 2017), the present UK transport system faces many challenges. The UK road transportation system is gradually taking steps to overcome the problems. As road transport is a significant source of both safety and environmental concerns. This research aims to explore the driving forces of smart road transport transformation, and implementation in the UK along with the challenges faced. In doing so the next section delves into the relevant literature review followed by methodology and findings. The paper finally concludes with recommendations.

## 2. Literature review

An extensive review of literature on drivers, current status of smart cities and the challenges are discussed in this section. Three main drivers include: technology, environment, and socio-economy (See Table 1). The technological advancement is clearly seen as strong impact on the cities in the recent years. It can be seen clearly that, the communication technologies (ICT) develops city management, enhances technical and social networks, and urban affordability. Within the technology as a driver, the review of literature revealed that technologies such as Big Data, Internet of Things and Artificial Intelligence are widely

implemented within the smart cities context. However, there is a lack of studies focusing on the UK smart road transport sector.

**Table 1: Literature on classification of drivers of smart cities development**

Drivers		Description	Source
Technology	Big data	Big volume of digital data contents through online services such as Facebook, Twitter, You Tube, Instagram and SnapChat	Olshannikova et al , 2017
		Data is transmitted to various smart applications through sensor devices or other cloud computing integrated devices	Hashem et al , 2016
		Big data development highlights information and communication tools in the cyber physical farm management cycle and it identifies the interconnection related to socio-economic challenges	Wolfert et al , 2017
	Internet of Things	IoT is widely in use for many multimedia application, smart transportation system and smart city design and deployment issues	KeertiKumar et al , 2016
		The implementation of IoT in transportation system means underlying technology and creating smart environments to increase their efficiency in tackling the transportation and environmental issues	Kyriazis et al , 2013
	Artificial Intelligence	Artificial Intelligence (AI) is a technology that is influencing every pace of life which enable people to reconsider how to integrate information, analyse data, and real time data usage for the purpose of improve decision making	West and Allen , 2018
		Artificial neural networks, expert system and hybrid intelligent system are computer based modelling tools that have recently aroused and found extensive recognition in many discipline for modelling complex real-world problem.	Bahrammirzaee , 2010
		China is a leading competitor and primarily focusing in the use of AI in military vehicles. While, Russia actively looking for opportunity in AI development and focused on robots in military	Hoadley and Lucas , 2018
Environment	Songdo, the Korean model of smart city was subjected to become one of the sustainable smart cities around the world		Yigitcanlar , et al, 2018
	Songdo, consist 40% of parks and green spaces and waste processing centre placed by the underground system and to recycle		Benedikt , 2016 ; Shwayri , 2013
	European Union aimed to reduce greenhouse gas emission in urban design through the implementation of innovation technologies		Ahvenniemi et al , 2017

	Cities have been setting high expectation on reaching the target of creating a clean future as shared by Covenant of Mayors' vision for 2050 to accelerate the decarbonisation	Covenant of Mayors for Climate & Energy , 2018
<b>Socio-economy</b>	By 2050, six hundred cities will generate almost 65% of world economic growth by contribute to a higher global GDP	Dobbs et al, 2012
	Smart cities indicated as the next evolution of 'new community management where urban problems converted into opportunities for business investment and profit earning	Anand and Marcco , 2018
	Global smart cities market size to grow reaching USD 2.57 trillion by 2050	Grand View Research , 2018
	Governments are obligated to protect citizen and their control over the active connection of local public groups, the police force, and the citizen such as the senior and disabled	Neirotti et al ,2014
	Level of observing has been focused by an increasing safety and security that desires to manage risks	Kitchin , 2014
	Safety and security features implemented with help of big data and data controls centres that joined and bind data stream collectively for example the installation of CCTV and street monitored camera are to monitor activity remotely	Firmino and Duarte, 2014

Big data is a trend of utilising software tools to store data and share data collected with the use of technology. Nowadays, big data has been a tool that facilitating individual, businesses and government to discover new solutions to certain problems. Data is a crucial aspect as when an asset is built, asset management goes on and the more data collected in, the asset is being constructed, the more the asset can be maintained in an efficient manner (Loshin, 2018). Furthermore, KeertiKumar *et al* (2016) mention that IoT is widely used for many multimedia application, smart transportation system and smart city design and deployment issues. The acceptance of IoT application is due to the power of the internet users that use smart phone technology and mobile communication standards. Kyriazis *et al* (2013) found that cities aimed at providing various modes of transportation related activities of daily living.

Artificial intelligence (AI) is defined as the theory of developing computer systems to have the ability to complete tasks that would normally be conducted by a human such as tasks requiring visualisation, speech or decision making (West and Allen, 2018). AI is being deployed into a variety of sector such as finance, national security, health care, transportation and smart cities. According to Yigitcanlar et al (2020) and Bahrammirzaee (2010), artificial neural networks, expert system and hybrid intelligent system are computer based modelling tools that have recently aroused and found extensive recognition in many discipline for

modelling complex real-world problem. Organisations have been adopting the use of AI to provide benefits for their business, AI systems are being implemented for example in the UK, all major motorways are to be converted into smart motorways which uses some sensors, computer intelligence and human interaction when needed through the review of the CCTV cameras to manage traffic on the motorways. AI is also used within construction organisations in the form of Common Data Environments where the organisation stores its information using the built-in system to recognise drawing/document names and references as each has a unique number allowing staff to find documents out of possible tens of thousands.

Encouragement of smart and sustainable environment is one of the main reasons behind the acceptance of smart cities concept across local government. For instance, Songdo, the Korean model of smart city was subjected to become one of the sustainable smart cities around the world (Yigitcanlar, 2018). Moreover, Masdar City in Abu Dhabi have expressed to associates with sustainable environmental. Masdar City aimed to be one of world's most sustainable urban developments powered by renewable energy. As a solution to the environmental challenges created by human activities, the suggestion on encouraging sustainable smart cities is the potential driving force to the development of urban cities.

A report from the McKinsey Global Institute, Urban world: Cities and the rise of consuming class, found that by 2050, six hundred cities will generate almost 65% of world economic growth that would contribute to a higher global GDP (Dobbs *et al*, 2012). In addition, as Anand and Marcco (2018) notes, smart cities indicated as the next evolution of 'new community management' where urban problems converted into opportunities for business investment and profit earning.

To move urbanisation management towards a citizen orientation, governments are obligated to protect citizen and their control over the active connection of local public groups, the police force, and the citizen such as the senior and disabled (Neirotti *et al* , 2014 ). In regards to collecting and monitoring information for crime prevention, information computer technology (ICT) has significant contribution towards achieving this goal. Although, UK is embracing the implementation of smart cities strategy within the country, nevertheless very little adoption can be witnessed in the road transport sector.

### **Current status of smart motorways**

During the past years, little investments has signified poor maintenance on the UK's road networks, with surfacing for example now reaching life expectancy. From the condition of the UK's road infrastructure through to the network issues relating to capacity and connectivity, the UK encounters similar issues as witnessed in different countries. With ever increasing demand on the roads, capacity issues deem some roads not sufficient (Elliot, 2015). Therefore, smart motorways are developed to control traffic flow which will enhance the network. In the UK, smart motorway were introduces in 2006 on the M42 in the West Midlands. UK have implemented four type of smart motorway which are *controlled motorways* (variable speed limits without hard shoulder), *dynamic hard shoulder* (variable speed limits with the hard shoulder), *all lane running* (variable speed limits with hard shoulder tuned into permanent lane and *through junction running* (its and older version of smart motorway and used when a hard shoulder used as a junction). These have been implemented on existing smart motorway (M1, M3, M4, M5, M6, M20, M25 M40, M42, M62, M90) operating in the UK (Woollaston, 2018).

The published literature on smart motorway emphasises improvement in both journey and time. The main aim of smart motorway is to reduce the congestion on the road, but currently its lack of information on CO<sub>2</sub> reduction. The Intelligent Transportation System (ITS) is usually placed in a transport infrastructure or in a vehicle for monitoring and controlling the traffic volume. The information is collected, processed and shared between service provider and the users. Mayor of London (2018) stated that 4,300 deaths are reported per year due to air quality related illness. The ITS mitigates the Ultra-Low Emission Zones (ULEZ) creating traffic free zones and Low Emissions Zones in the cities and reduce the pollution and health illness due to air pollutions. Intelligent transportation system (ITS) is integrated technologies based on wireless communication, radar, sensor and information technologies (Heather *et al*, 2015).

Smart phone is widely used globally and has become an essential communication tool for people worldwide. The usage of social media applications such as Twitter, Instagram and Facebook is gaining popularity. The feature of posting daily activities of people on social media creates a potential raw source of transportation data for planning and operation (Khan *et al*, 2017 p. 263). The real time data shared in the social media platform is a source of information for road users (Ruiz *et al*, 2018). The road users become aware on the traffic information and able to plan the their journey. This social media platform creates a good communication tools between the road users and the service provider. As a result, the local authorities are able to achieve their aim on reducing congestion on the road. As smart phones is an essential tool to communicate among people and infrastructure, there are many mobile applications have been developed for a certain purpose in different sector around the world.

The use of internet and mobile application also has the significant impact in transportation. For instance, Waze is a traffic and navigation application assisting many road users in the UK. Clark (2018) stated that Waze is connecting citizens by providing traffic collision report faster than 999 call takes to make its way to their control centre. As stated by Richards (2018) Edinburgh ranked the top city in implementing transport application. The report shows that 88% of travellers in Edinburgh make use of the internet and mobile application to aid their journey to locate, track and pay for transport, whereas, Newcastle scored 56% which is the lowest out of 12 surveys reported.

The same survey reported that mobile application are used to buy tickets, view departures times, live traffic report, top up travels cards, map viewing, directions and locating, pay for parking, cycle hire, and taxi hire. On the other hand, London based App called CityMapper is competing with Google Maps and had secure \$10 million funding and estimated that one billions commuters to access the maps service monthly. The development of Uber and myTaxi App eases the travellers to provide live information on the location of the local Uber and myTaxi driver, which offers pick up service. The travel information to be entered online and payment done on the application. Nowadays, Uber and myTaxi mobile Apps become more popular among the travellers (Gibbs, 2018).

The traffic management system becomes easier due to availability of internet. Siemens (2017) had introduced application module for Stratos Remote Monitoring with direct IP connectivity to the Stratos Outstation or ST950 controller. The traffic signals module brings new experience in the usage this new application. The deployment of cloud based traffic management system can be seen in Portsmouth, UK. The City of Portsmouth has installed Bliptrack Bluetooth and Wi-Fi sensing around the city. The Portsmouth City Council's



Traffic Department access the information on journey time, average speed and traffic congestion by data feed into cloud based traffic management system (Department of Transport, 2014).

### **Challenges for UK road transport infrastructure development and maintenance**

Investment is vital in relation to plan for UK road transport infrastructure and UK is facing challenges in getting the investment in place to finance the road infrastructure. According to study by management consultancy firm McKinsey, UK is ranked 24<sup>th</sup> out of 148 countries in relation to the quality of overall infrastructure. Local Government Association (2018) estimated that by 2025, England will face almost £8 billion of funding gap. Although local government had introduced a number of measures to overcome the challenges in the UK road transport infrastructure, a survey conducted by Local Government Association Transport showed that uncertainty and lack of funding are clearly the barriers for implementation of UK smart road transport infrastructure. As made evident by the variety of theories and findings, funding is always becoming a 'hot topic' between local authorities when considering the application of road transportation scheme.

Kanabkaew et al (2013) had asserted that the major contributor to air pollution and the greenhouse gases GHGs are vehicle emissions. Therefore, the transport sector could be considered as direct responsible. The adoption of electric vehicles (EVs) is one effective strategy to reduce GHG emissions that contribute to climate change. The widespread electrification of transport will not only offer potential to reduce road transport emissions, but also to unlock other smart city opportunities. This includes solutions in mobility, competitiveness in renewable energy use, residential and commercial building, wider urban systems, citizen engagement and behaviour. The drive behind the transferral towards EVs is now clearer than ever. Vaughan (2018) highlighted that ministers has been urged to bring forward the ban on petrol and diesel car sales from 2040 policy decision by UK government. Two of major car manufacturer Volvo and BMW have agreed to produce only electric version car starting 2019 (National Grid, 2018). The demand of EVs has seen an astonishing surge in the UK for last four years. According to Next Green Car (2018) the figure has shown a dramatic growth of the EV car and van market. To achieve the government target in cleaner car fuels and low carbon cars, the government has introduced a set of coordinated economic schemes to encourage vehicle users to use electric vehicle. The low-emission vehicles for a plug-in grant are for car dealerships and manufacturers can get grants to reduce the electric car's price (Gov UK, 2018).

Although the UK government has been operating a plug in car grant since 2011, the registered electric cars lower than 1000. The existing version of the scheme has been renewed since 2016 and expected to continue subsidising hybrid and electric car that cost less than 35 per cent (Priday, 2018). However, ONS (2017) underlined that the most significant barrier in buying demand of electric car is the lack of charging station as the vehicle powered by battery. Related to this issue, Gov UK (2018) the UK took major step to introduce new law to improve customer confident in charging EVs and revolutionise the insurance rules. Autonomous and EVs Act is present to provide more electric charging point on motorway and the revolutionise insurance to scheme to cover self-driving vehicles. Nevertheless, more charging points built need a standardised grid of power supply. The UK National Grid had assured that currently, they have sufficient energy to support the nation for EVs users. But will be an issue if the users charge the vehicles at the same time as the charging point's ability to charge concurrently is not certain (Ambrose, 2018).

A hybrid electric bus combines diesel engine and an electric motor sources in the vehicle drive train. Four major hybrids bus manufacturer are Wright Bus, Alexander Dennis, Volvo and Optare. As National Express UK Bus operate as a main fleet provider nationally, since the Green Bus Fund introduced, the company had procured 48 hybrid bus and 18 (Volvo B5LH) of it were deployed in Birmingham.

The hybrid bus performance showed improvement when newly purchased but the performance drop after 5 years due to the batteries showing significant sign of degradation (Low Carbon Vehicle Partnership, 2017). On the other hand, Intelligent Transport (2018) highlighted that North-East England Council has invested roughly £46 million into upgrading bus technology and sustainable north-east fleet to over last 5 years. North East England becomes the first region to trail fully electric to develop towards their goal of operation sustainable bus fleet in the UK. The Yutong Electric is designed and made in China and in use in selected cities across the UK including London and Nottingham. Yutong Electric is certainly help reducing the carbon footprint and enhances passenger comfort by providing best features which conventional bus does not have such as internal USB charging ports, air conditioning and information screens.

### **Research Gap**

The development of smart cities around the world is being shape by local and national by its own socio-economic essentials. The phenomena of big data, IoT and AI has contributed to smart city transformation. The UK is also experiencing the technology growth in terms of implementing smart city features in the road transport infrastructure. Even though UK is growing and taking the chances in the shaping the road transport infrastructures towards smart city strategies. The UK has started the construction of smart motorways to assist with creating an efficient economy within infrastructure. The development of a Smart Motorway Programme (SMP) was aimed at raising the capacity of the UK's existing roads instead of constructing new roads. This improvement will enable commuters to have better connections around the key cities in the UK. The government decided to invest billions of pounds between 2015-2020 to improve efficiency and safety, while improving the capacity. The road investment in the UK has been slow compared to other European countries which have created a drag in the economy, however with this massive investment the economy growth is set to rise. Despite the growing number of articles on the topic, there is no scholarly work that explores the driving forces of smart road transport transformation, and implementation in the UK road network. The paper seeks to address the following three research questions include: (1) What are the key drivers of smart road transport transformation?; (2) What is the current status of smart road transport implementation in UK?; and (3) What are the challenges of the smart road transport development in the UK?

### **3. Methodology**

To explore in-depth understanding of the current study research problem, the research focuses on the perceptions of individuals relating to the driving forces of smart road transport transformation, and implementation in the UK along with the challenges faced. Therefore, to gain an understanding of experts perceptions, it is necessary to use a methodology that elicits interviewees' inner thoughts and feelings. The overall research approach adopted for this research was qualitative methodology. Adopting a qualitative approach in obtaining research



involves a small number of in depth responses through interviews whereas a quantitative approach would involve a large spread of participants in the form of questionnaires. Utilising a qualitative approach would provide deeper level of insight which is ideal for area where there is sparse knowledge available (Liamputtong and Ezzy, 2005).

The purpose of qualitative research is discovering and understanding meanings by individual or group for a problem or an issue (Creswell, 2011). Furthermore, qualitative research is carried out to understand meanings, interpretations, and/or to look at, describe and understand experience of people involved in the given context (Wisker, 2008). Semi-structured interviews provide some flexibility and it is one of the ways to obtain a realistic picture of an individual's view (McCormack and Hill, 1997). Semi-structured interview was conducted between November and December 2018. These interviews were recorded and transcribed for analysis.

The selection of the interviewees was based on their job title, skills and knowledge in the UK road transport sector. A breakdown of professionals who were interviewed for the study is presented in Table 2. The participants were grouped by their job title: directors, consultants and managers and had between 10 to 20 years of experience in the UK transport sector and in particular they had relevant experience on smart road transport implementation issues. The area of expertise of the interviewees include: smart transport solution implementations; local transport strategies management; intelligent transport systems implementation; digitalisation of the transport sector; leadership of smart motorway projects; smart transport planning; technology adoption and project management in transportation sector.

Robbins (1994) noted that the suitable number of experts for the qualitative research may range from 5 to 50. Murry and Hammons (1995) suggested that for the qualitative decision-making process the number of experts may be in the range of 10 to 30. To ensure greater dependability and transferability (Creswell, 2014), a total of 16 experts were interviewed in the UK road transport sector.

An important sample size issue in qualitative research involves saturation of information (Strauss and Corbin, 1998). Saturation is a term used to describe the point when no new insights or range of ideas are generated through adding more data. In this study, data was collected until no new aspects of the smart road transport implementation issues were revealed. In this study, actual saturation of data occurred before the 15th interview. Therefore, 16 interviews were conducted.

Table 2: A breakdown of professionals who were interviewed for the study

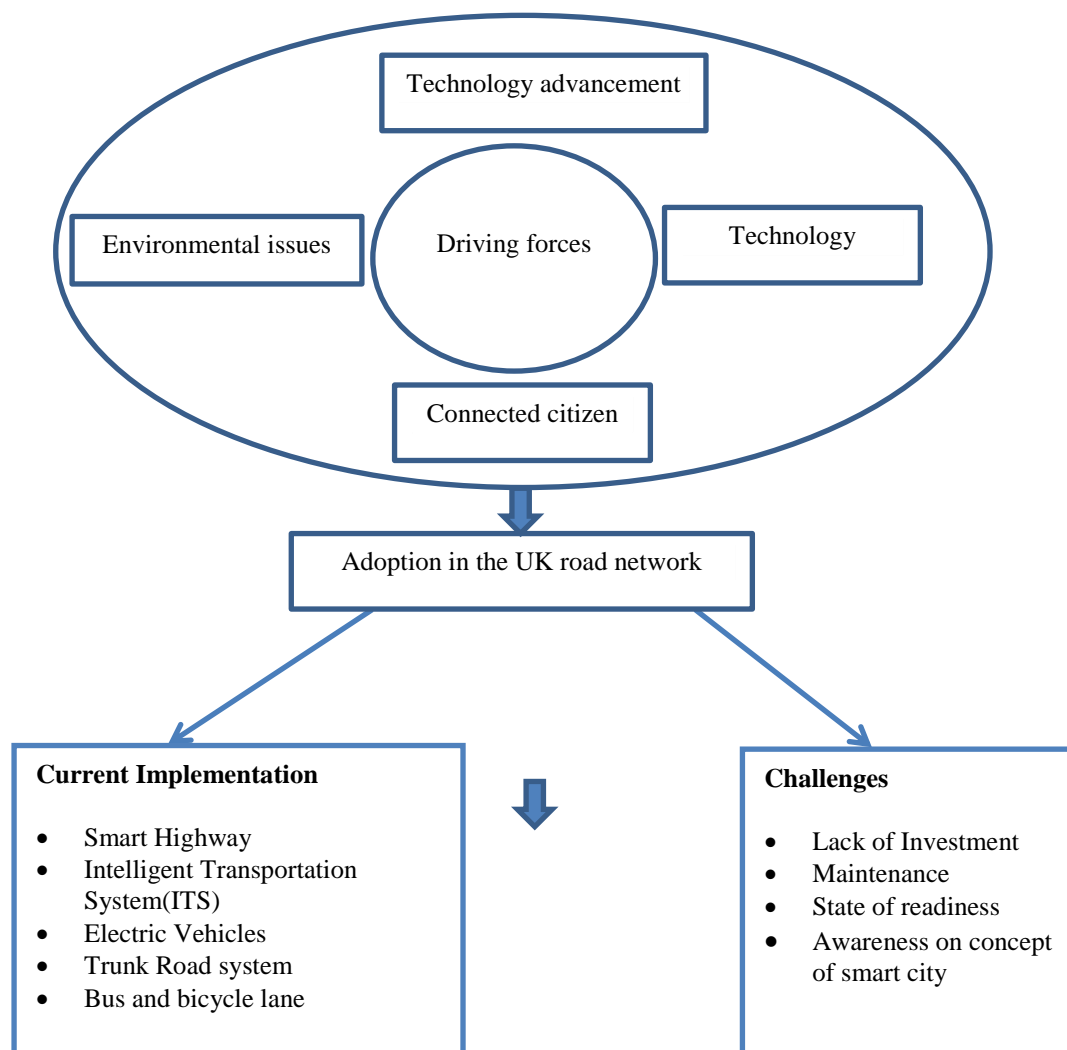
<b>Responsibility of interviewee in the organization</b>	<b>No. of Interviews</b>
<b>Directors</b>	
• Smart motorways programme director	2
• Director for transport	1
• Regional Director – Transport modelling	1
• Associate director for transport planning	2
<b>Consultants</b>	
• Principal consultant – transport technology	2
• Senior transport consultant	1
• Consultant transport planner	2
<b>Managers</b>	
• Smart motorway manager	2
• Intelligent transport manager	1
• Transport planning manager	2
<b>Total</b>	<b>16</b>

As a part of analysing data, the transcribed interviews imported to the computer aided system called Nvivo 11. To get a clear image of the similarity and differences opinions discussed, the coding method used to determine the main point that mentioned. In order to analyse the script or text and recover the frequently words used within the text, word frequency query test has been executed. The data has been analysed based on the similarity of text and the meaning expressed by the participants. In generating the main points, the text was carefully analysed with trend and expression showed by the participants. The content analysis technique is highly flexible that used in this research.

Triangulation of data made possible through these means contributes to the reliability and validity of the study. The concept of triangulation is based on the assumption that any bias inherent in particular data sources, investigator or method used would be nullified when used in conjunction with other sources of data, investigators or methods (Saunders et al., 2019). In this study, relevant literature was used to confirm and support findings found from the data collected. In certain cases, data obtained from an organisation was triangulated through inquiring more than one employee.

#### 4. Findings and discussion

The findings are presented in three themes (See Figure 1): driving force of smart road transport transformation; current status of smart road transport implementation; challenges of the smart road transport implementation. In this study, interviewees were asked to list and describe key drivers of smart road transport transformation, current status of smart road transport implementation and challenges of the smart road transport development in the UK through interviews.



**Figure1:** Conceptual diagram of the findings

##### 4.1 Driving forces of smart road transport transformation

In this study, overwhelmingly 94% (15 of the 16) of the interviewees emphasised that a driving force of development of smart road transport is associated with technological advancement. For instance, one of the interviewees stated that:

“I think the factor is growth in technology. What technology is able to give us by the way of what we can plan how we want, how we want the city to functions. I think it is the bedrock of the smart city”.

Analysis of the above statement reveals the significant element of smart road transport transformation remain as technology. In this context, 81% (13 of the 16) of the interviewees noted that connecting citizen is a key to the smart road transport transformation. In today's global urbanisation, citizen always upgrading their quality of life and technology is becoming a primary reason in connecting people in solving their daily life problems. Therefore, the experts consider that connected citizen's plays an important role in creating a smart city. Based on the analysis, 63% (10 of the 16) of the interviewees expressed the belief that the driving factor of smart road transport transformation is by solving environmental issues such as pollution and congestion problems. Of the interviewees, 38% (6 of the 16) suggested that to accommodate the safety of the public or citizen, city leader obligated to provide protection and safety features for the public. Although, experts suggested that technology is just a factor to smart road transport, the connections between aspects of driving force to smart road transport is demonstrated that primary feature to be the growth of technology.

As finding of earlier studies, digital technology such as big data, IoT and artificial intelligence are the core driving factor to the development of smart road transport. The recognition by Olshannikova *et al.*, (2017) the power of big data has been categorised by volume, velocity and variety and these data derive from the expansion of social media platform and computer technology. Moreover, the Internet of Things (IoT) and artificial intelligence is fast growing technology which satisfy the needs of the growth of smart road transport. It was theorised that participants' belief that the introduction to new digital technology is great and believed technology is bedrock of the smart road transport. Therefore, one of the major driving forces to the smart road transport development is technology.

#### **4.2. Current status of smart road transport implementation**

Of the interviewees, 88% (14 of the 16) mentioned local roads classified at the lower tier on the of the UK road infrastructure hierarchy. For instance, one of the interviewees stated that:

“The local roads level the status is less mature and I don't think we are prepared as ready to enable smart cities”.

On the other hand, in the current study, 81% (13 of the 16) of the interviewees noted that the motorway scheme is well developed in the UK road network to form part of the smart road transport transformation. For example, one of the interviewees stated that:

“We have different tier of UK road network which is strategic road network and it's managed by Highway England. Where you got the motorway and trunk roads. That's the motorways highest tier of road network”.

In embracing the technology solutions working towards smart cities, motorway scheme is well equipped with dynamic hard shoulder running, and variable speed limits. For instance, one of the interviewees stated that:

“We work for government and we work for the department of transport and our aim are to ensure that the motorway strategic road network connects businesses, people and families, safely and reliably so we build new project and maintain the existing motorway network and monitor the motorway network to ensure that businesses can use the network reliably and safely”.

Many new build projects in relation to the motorway scheme have received consideration and investment for the period of 2015-2020 and 2020-2025. Of the interviewees, 69% (11 of the 16) indicated that trunk road or major road link to the motorway has established and implemented with well-equipped facilities enable the smart connectivity. For instance, one of the first All Lane Running (ALR) smart motorways constructed was the M25 in the UK. London is known to contain a vast number of commuters and during its busiest times, there can be congestion for up to an hour to hour and a half which leads to the decision of converting the M25 motorway into a Smart Motorway Programme. This scheme was used as a trial Smart Motorway and was carefully monitored to validate that the theory they are making the most out of the existing asset without affecting safety was true.

Highways England (HE), who own the motorways in the whole of England, produce a report every year showing the results of these trials, the interim report results dated May 2015-April 2016 (Office of Rail and Road, 2016), the results showed that the Smart Motorway Programme had majorly improve congestion, in addition, it saw a decrease in journey times for road users. It was observed that areas where would normally experience a high volume of congestion between Junction 23 and Junction 27 were massively impacted and traffic was a lot smoother. Journey times were reduced by approximately four times the usual time it would normally take with congestion. In this context, experts believe that the motorway and trunk road system control and managed by good monitoring system which identified as Intelligent Transportation System (ITS). It plays an important role in connecting and communicating with road transport infrastructure through digital technology solutions.

Similarly, the A14 is a stretch of motorway that connects the midlands to central UK. It is currently being constructed where the improvement is to convert it into a 3-lane motorway with smart technology similar to a smart motorway. Currently at this project, the use of ICT's are being utilised within the construction process to allow for a more efficient construction process. During construction, drones were utilised to obtain a point cloud survey of the entire project. This lead to efficiency being obtained during the survey process as otherwise surveyors are to go out on site and manually survey the area, in addition to being more efficient, using drones allowed for a total survey of the whole area including trees and nearby houses which would have been missed if conducted manually. For the project, obtaining an accurate point cloud allowed the team to be able to visualise what was currently out on site prior to the works commencing with data provided on the point cloud.

One of the parent companies who are working at this project is also using other forms of smart technology such as AI. This organisation plans of using AI to produce planning programmes for future project which are usually manual tasks. With the use of AI, the programmes and schedules of work can be automatically generated for any scale of any

project minimising error in the schedules with the use of historic projects' data from the organisation.

Big Data is a key factor that is being implemented widely. In the UK, all construction projects are to implement a minimum of Level 2 BIM (Building Information Model). This requires organisations to collect and store asset data where each asset within the construction process has its own unique set of data fields to be collected and stored. Both projects mentioned within this research have implemented this and have been collecting asset data which is to be used in future for asset maintenance purposes.

In this current study, 56% (9 of the 16) of the interviewees asserted that overall existing road infrastructure is satisfactory but a lot more can be done comparison to standards set by nearby European countries. On the other hand, 44% (7 of the 16) of the interviewees suggested that bus and bicycle lane can be promoted in developing new ways of travel mode. Although current implementation is acceptable, there's a lot more can be learnt from other country's adoption in road network and looking forward on how the implementation benefit the community, business and economics of the country in overall.

Overall, the current implementation of motorway system in UK is well equipped with facilities that enable smart connectivity. The unanimous recognition by the experts that motorway scheme is at the highest tier of the road network once again echoes the finding of earlier studies (RAC, 2018; Gov UK, 2018; Woollaston, 2018). The smart motorway experts implement smart technology solutions to connects the controlled motorways (variable speed limits without hard shoulder), dynamic hard shoulder (variable speed limits with the hard shoulder), all lane running (variable speed limits with hard shoulder tuned into permanent lane and through junction running). In addition to the experts recognition to the smart motorways scheme, believed that the motorway and trunk road system control and managed by excellent monitoring system identifies as ITS. This outstanding monitoring system not only monitors life span of infrastructure but also help to monitor congestion and safety of the road users. On the other hand, local roads at the lowest level where the local roads classified as being less mature and it's not ready to enable the smart road transport.

The government initiatives for a future implementation can be seen as the drive behind change towards electric vehicles. The electric vehicle has been identified to reduce gas emission in the air (Gov UK, 2018; Priday, 2018). However, the agreed recognition by the experts that the most significant barriers in buying electric cars are the lack of charging points. In addition, in the context of implementing autonomous vehicles, government is still analysing.

Nowadays, technologies become a tool to connect people and other services around the world. The uses of social media significantly impact the user's daily activities. The data shared on social media platform such as Twitter, Facebook and Instagram is a potential raw data which is useful for road users (Khan *et al.*, 2017; Salas Jones *et al.*, 2018) and once again echoes comments made by some of the interviewees. Although current implementation is acceptable, there's a lot more can be learn from other country's embracing in road network and looking forward on how the implementation benefit the community, business and economics of the country in overall.

#### **4.4. Challenges of the smart road transport development in the UK**



In this current study, overwhelmingly 94% (15 of the 16) of the interviewees noted that as investment is most captured challenges in implementation of smart infrastructure in the road network. The lack of investment is not surprisingly acknowledged as barrier to enable smart road network. For instance, one of the interviewees noted that:

“I think around investment because that is always going to be a challenge. You can cheer technology and you cheers all the way 4G, 5G whatever is coming from horizon. But it’s so fast moving that you have to be very careful to prioritise where you want to invest. I think perhaps the lack of investment, is a huge barrier to enable smart city to come forward and support the UK road”.

In relation to the lack of investment, it is difficult to concentrate funding and to capture benefits during this period in which transport is in an inflection point. Most of the development works is invested around big city such as London, whereas smaller city is struggling to get investors to spend for the road infrastructure growth. The cost of implementation of the smart infrastructure in road network could be great; therefore the question whether it can be funded is debateable. Of the interviewees, 88% (14 of the 16) noted that the state of readiness is the barrier of smart road transport implementation. The road network facilitates the movement of people, goods and services. It is doubtful if the actors of the system are fully embracing the technology in road network context. For example, one of the interviewees stated that:

“The future of autonomous vehicles is uncertain. Therefore the demand needs to be based on assumption”.

This indicates that the UK is in its infancy for implementing smart road transport elements. According to the current study 63% (10 of the 16) of the interviewees noted that maintenance as another challenges in current road network. UK referred as an old country and had implemented old road infrastructure. Adequate information and knowledge are very important for maintenance. Since UK is constantly refreshing its road network, the quality of the road has been jeopardise and the condition of the road is the biggest concern. For instance, one of the interviewees noted that:

“It’s very important to time the development scheme as the traffic can be controlled to avoid self-cause congestion to the motorist during the maintenance works in progress”.

Another interviewee identified that sustainable and smart road transport needs to be included within the education system where this play important role in shaping the communities to be aware on the future implementation. The awareness need to be created not limited within the education system, communities need to be alerted by those initiates that able to provide real-life benefit.

As shown by previous studies that there are major challenges of the smart road development in the UK road transport infrastructure which is related to maintaining and repair the deteriorated infrastructure (HM Treasury, 2010; House of Commons, 2014). It is essential to have predicted budget to be able to spend for the improvement works to maintain strategic road infrastructure. The allocated budget to be utilising efficiently for further planning on cost-effective maintenance works. Adequate knowledge and information of road infrastructure and maintenance cost is needed to prevent inefficiency in planning for the scheduled maintenance work. It was theorised that interviewees belief that UK has ageing

infrastructure where these infrastructure need to revamp to maximise capacity due to the economy expansion, demographic and social changes. Although some elements of smart road transport are certain, it is doubtful if the actors of the system are fully embracing the technology in road network context.

## 5. Conclusion and future research

An understanding of the concept of smart road transport is very important to create awareness of the benefits and the way it works. A wider collaboration between the every sector is crucial to create a successful smart road transport. The trend of smart road transport implementation in the UK is less mature. The role of stakeholder is important as a driver to smart road transport solution. A transformation of a city is depending on its stakeholder such as city planner in setting an approach for promising development of a city or country. Smart road transport transformation can produce a phase of financial growth by attracting businesses and users. These implementations have the potential to increase the GDP of a country as whole. The UK has ageing infrastructure where these infrastructure need to revamp to maximise capacity due to the economy expansion, demographic and social changes. The adoption in the UK road transportation shows overall satisfactory but only around the urban area; however the rural area needs a proper planning in relation to embracing the smart road transport elements. Investment deficit and maintenance is the significant challenge fronted by the decision makers for the overall government strategy on infrastructure development. Based on findings and conclusions of the study, key recommendations for practitioner are drawn as below:

- Defining the realistic vision of smart road transport and appreciate learning from other countries. By clearly state the objectives and outlining the accurate budget needed.
- Leadership and a wider collaboration on standards between every sector to create a successful smart road transport.
- Create awareness on the concept of smart road transport, the benefits and how it works.
- Build a research hub on smart transportation elements before implementation.
- Connecting the community through social media platform on the progress of smart road transport development.

The study contributes to the field of digitalisation of road transport sector. This paper reveals the key driving forces of smart road transport transformation, the current status of smart road transport implementation in UK and challenges of the smart road transport development in the UK.

Despite the novel insights provided by this study, it has some limitations. The number of interviewees in this study is only 16. Nonetheless, this limitation provides fertile grounds for further studies regarding this subject area and in that regards a longitudinal case-study approach involving multiple methods of data collection (e.g. interview, observation, and documentary analysis) will be useful in unearthing further empirical realities. Given that the research reported in this paper is largely exploratory by nature, the results presented are only tentative and of limited value for the purpose of generalisability. Furthermore, the findings of this paper are limited to the UK road transport sector only; as such, the level of generalisability outside this context may be very limited. However, we argue that the results obtained are useful to similar developed countries.

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